Power HIL Simulator (SimP)

A prototype to develop a high bandwidth interface

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Hydro Québec

Presentation overview

> SimP at a glance

Presentation overview

- SimP at a glance
- Interface issue

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- **Interface issue**
- **Prototype design:**
  - Power amplifier
  - Controller
  - Simulator

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- **Conclusion**

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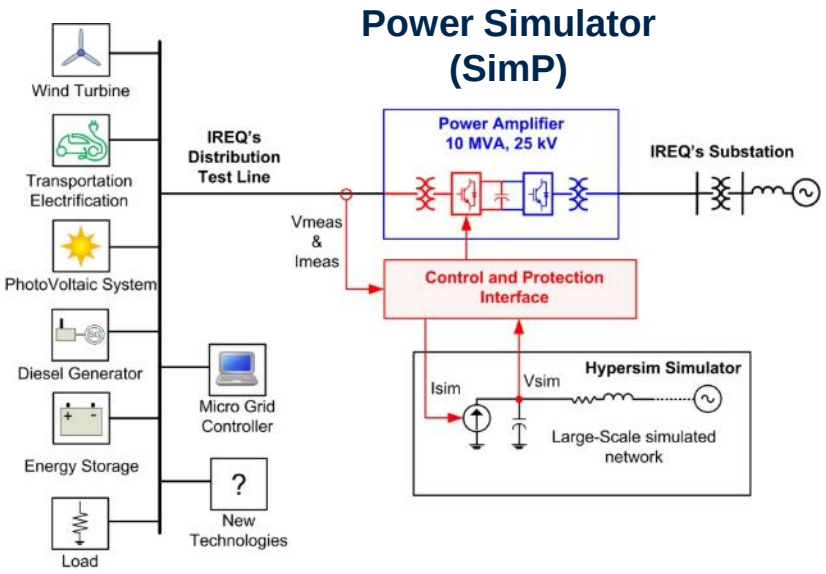
- Research & Testing Infrastructure for the validation of simulation models and for studying the dynamic behavior of electrical equipments connected to their power system.
- Scope: Smart Grid, Energy Storage, Renewable Energy Integration, ground transportation electrification



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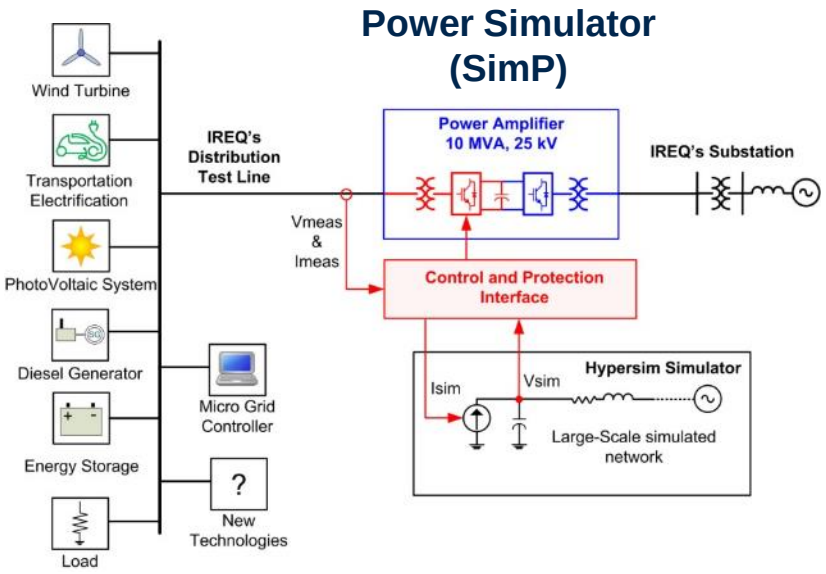

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- Preliminary project consisting to the implementation of a prototype (low power) of a Power Simulator controlled in closed-loop by a real-time simulated power system (Hypersim simulator)

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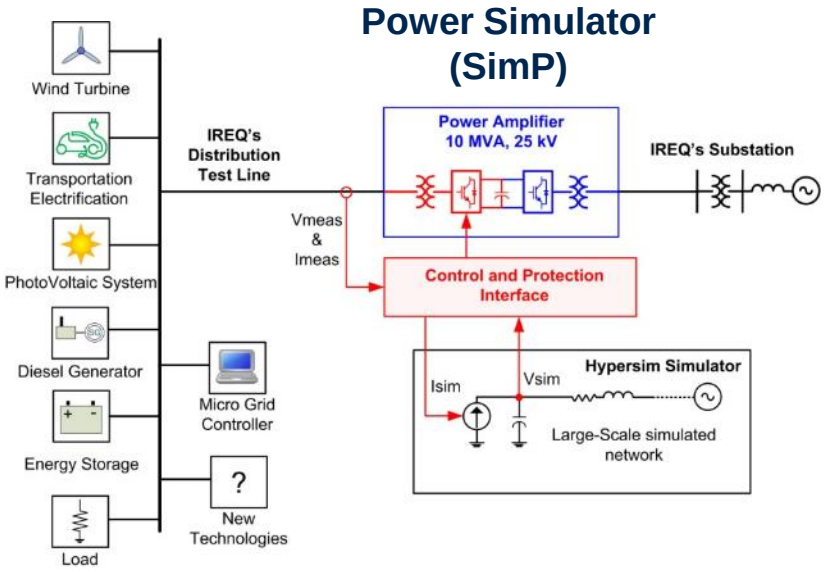

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- Preliminary project consisting to the implementation of a prototype (low power) of a Power Simulator controlled in closed-loop by a real-time simulated power system (Hypersim simulator)

>Project Outcomes

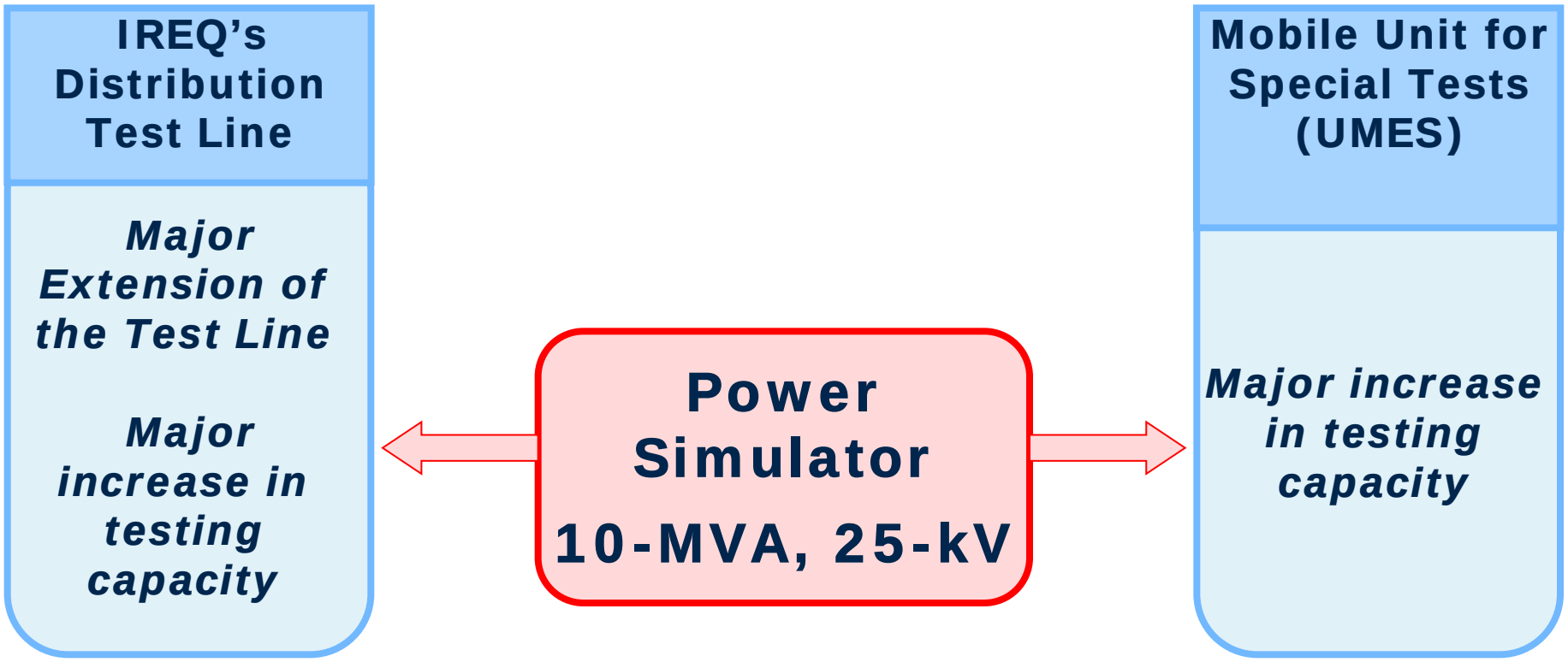
- World-class equipment
- Important extension of the IREQ's test line
- Major increase in testing capability
- Possibility of collaborations and partnerships on various projects

Context

Power Simulator

10-MVA, 25-kV

Context


IREQ's Distribution Test Line
Major Extension of the Test Line
Major increase in testing capacity
Power Simulator
10-MVA, 25-kV
Mobile Unit for Special Tests (UMES)
Major increase in testing capacity

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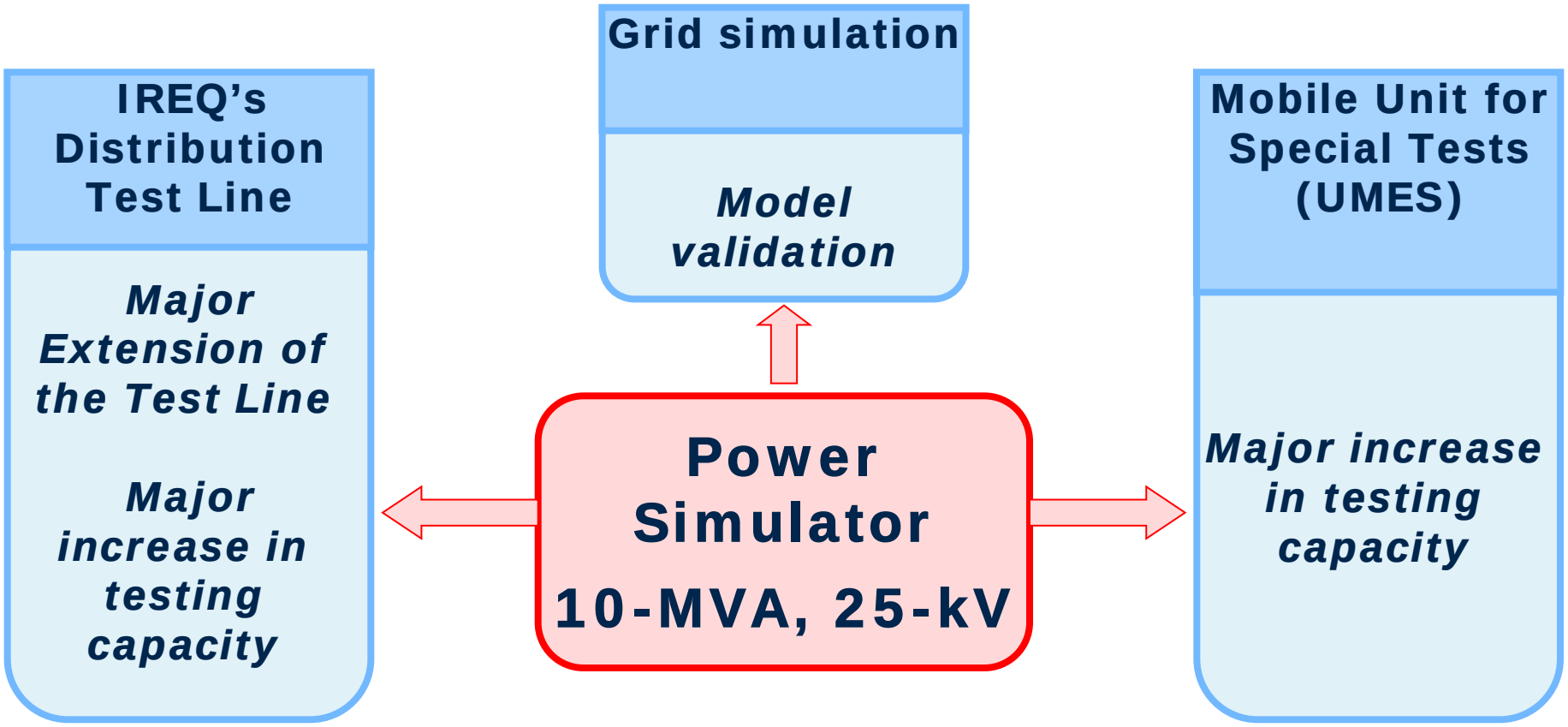
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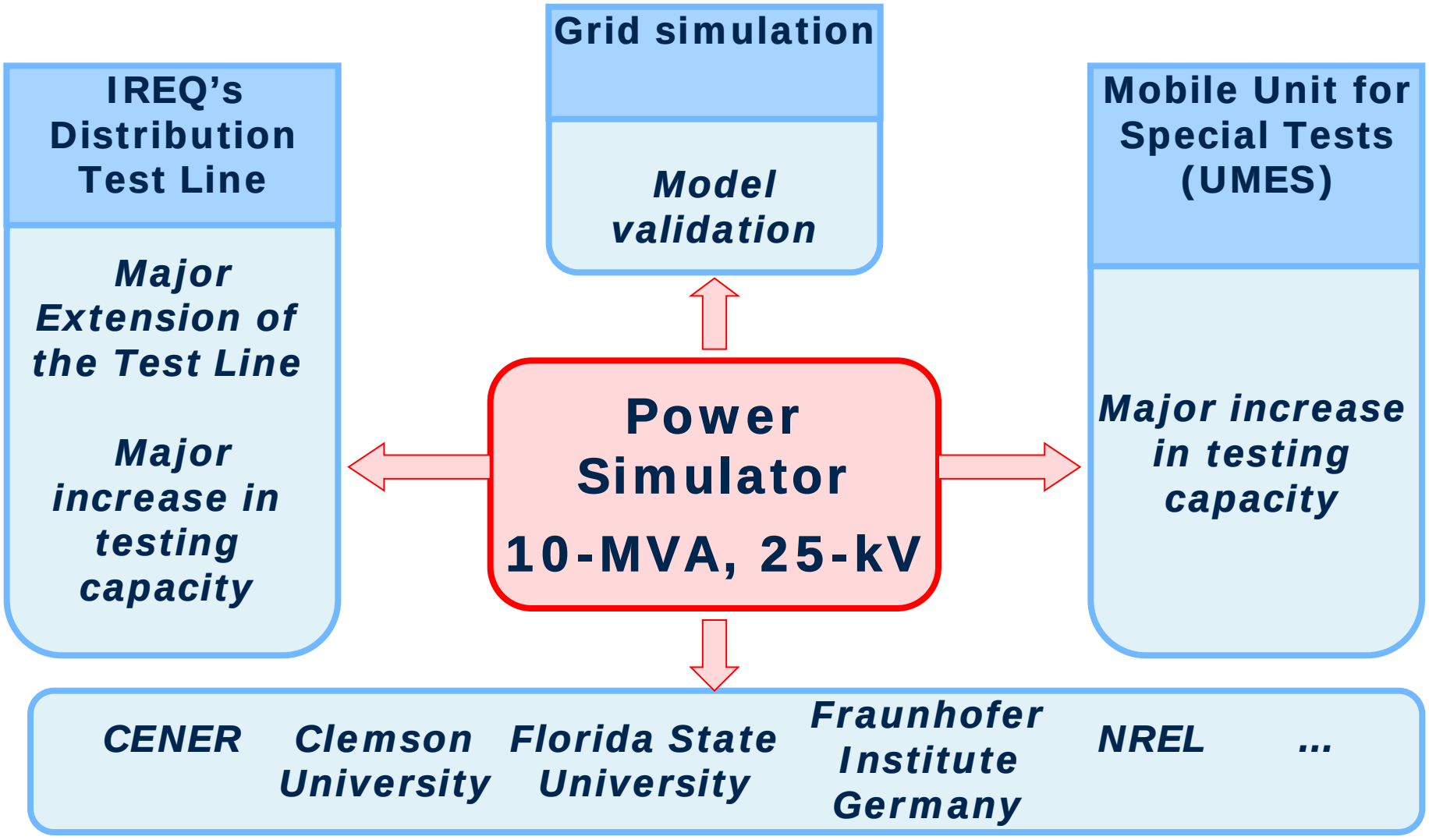
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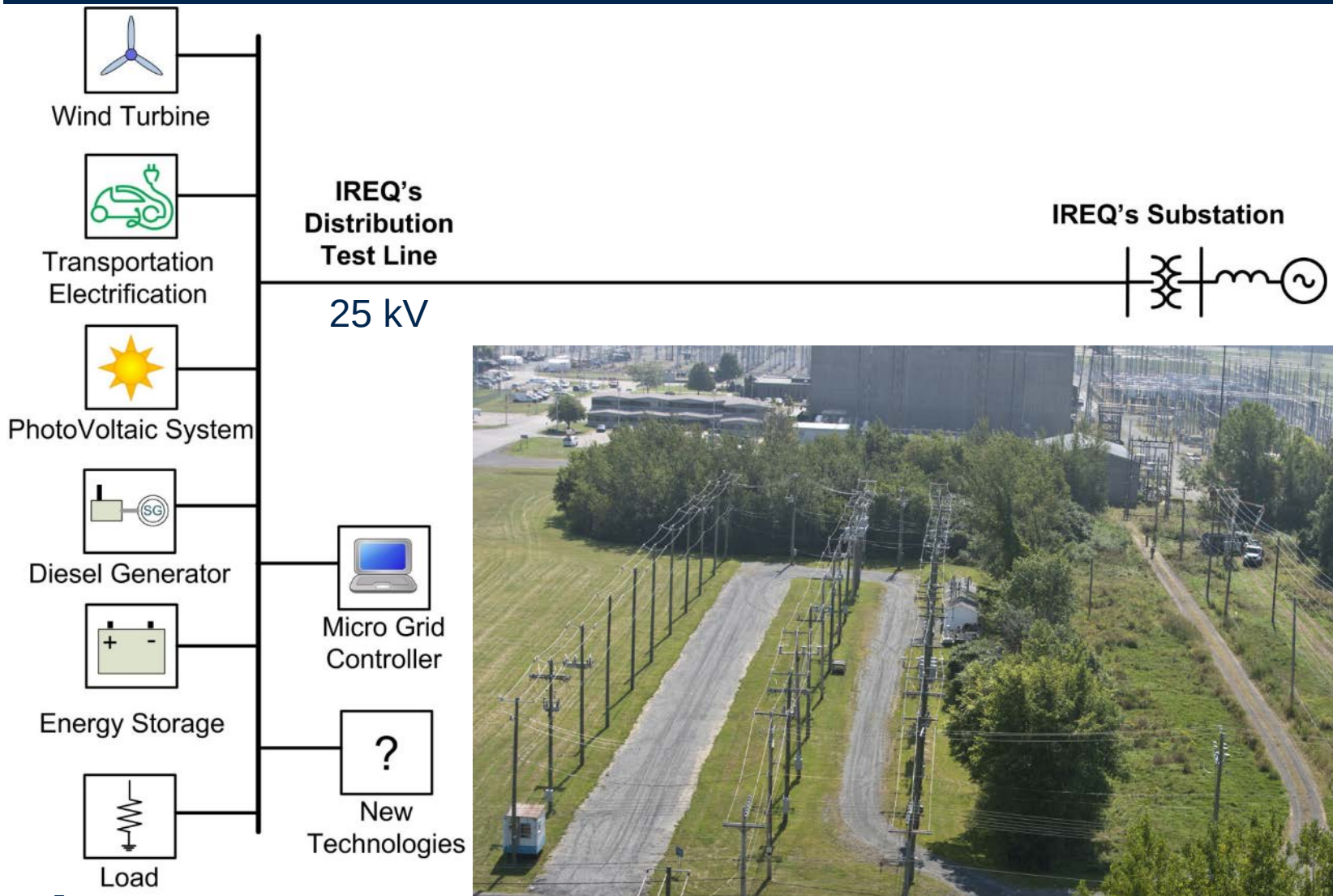
CENER
Clemson University
Florida State University
Fraunhofer Institute Germany
NREL
...

What is it?

What is it?


Wind Turbine
Transportation Electrification
PhotoVoltaic System
Diesel Generator
Energy Storage
Load
IREQ's Distribution Test Line
25 kV
IREQ's Substation
Micro Grid Controller
?
New Technologies

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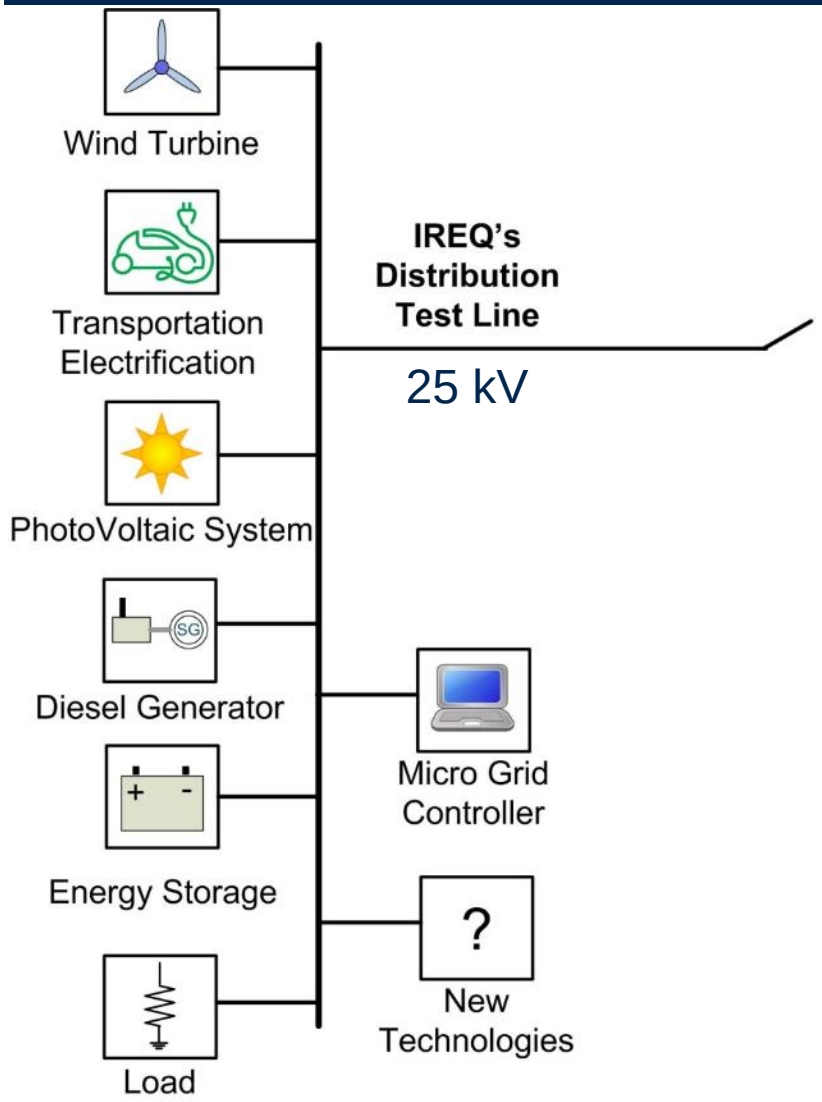
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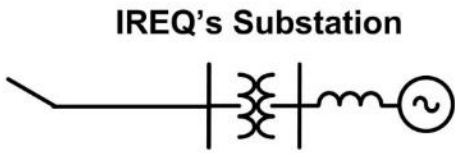
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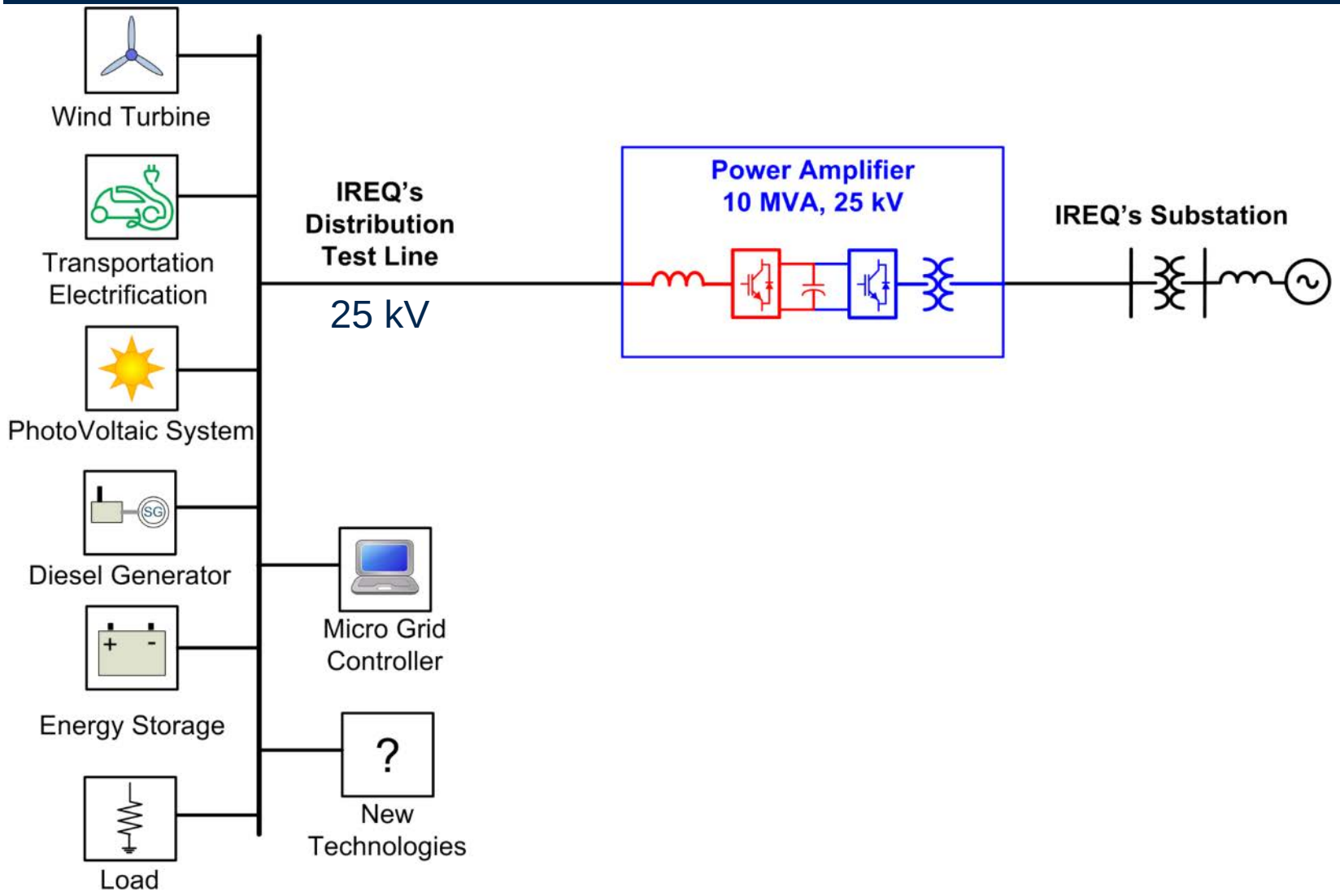
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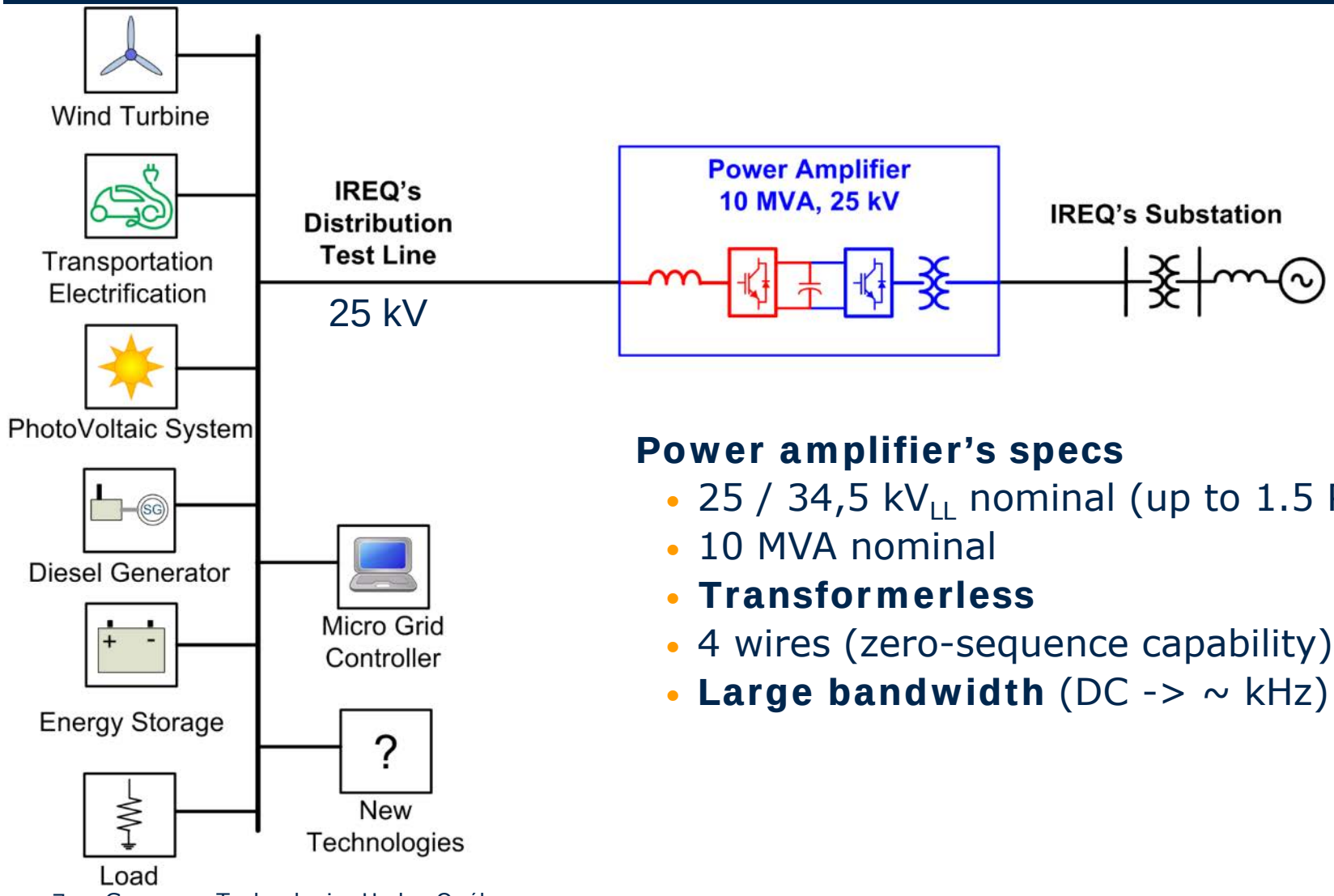

Power amplifier's specs

- 25 / 34,5 kV_{LL} nominal (up to 1.5 PU)
- 10 MVA nominal
- **Transformerless**
- 4 wires (zero-sequence capability)
- **Large bandwidth** (DC -> ~ kHz)

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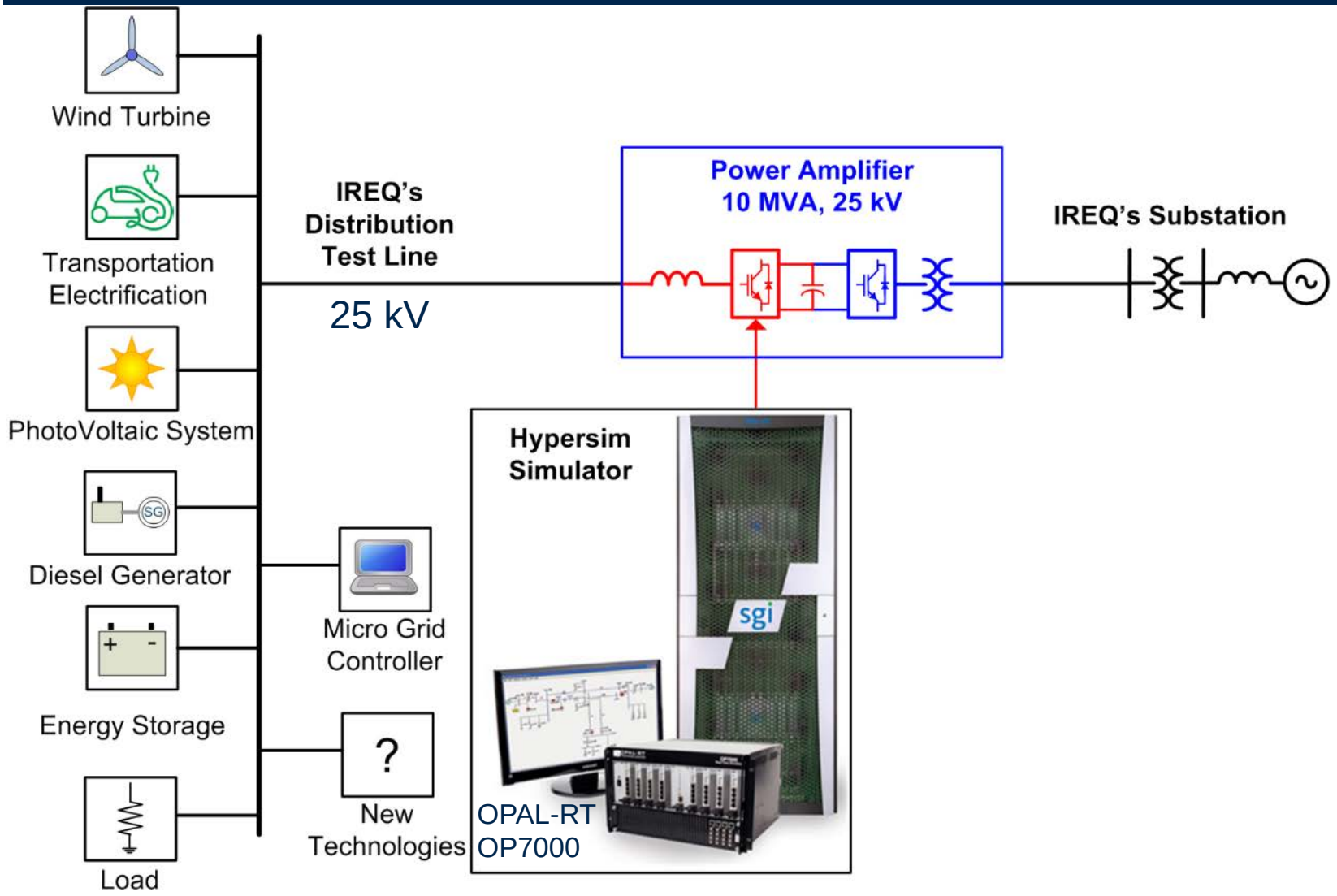
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Hypersim Simulator
sgi
OPAL-RT OP7000

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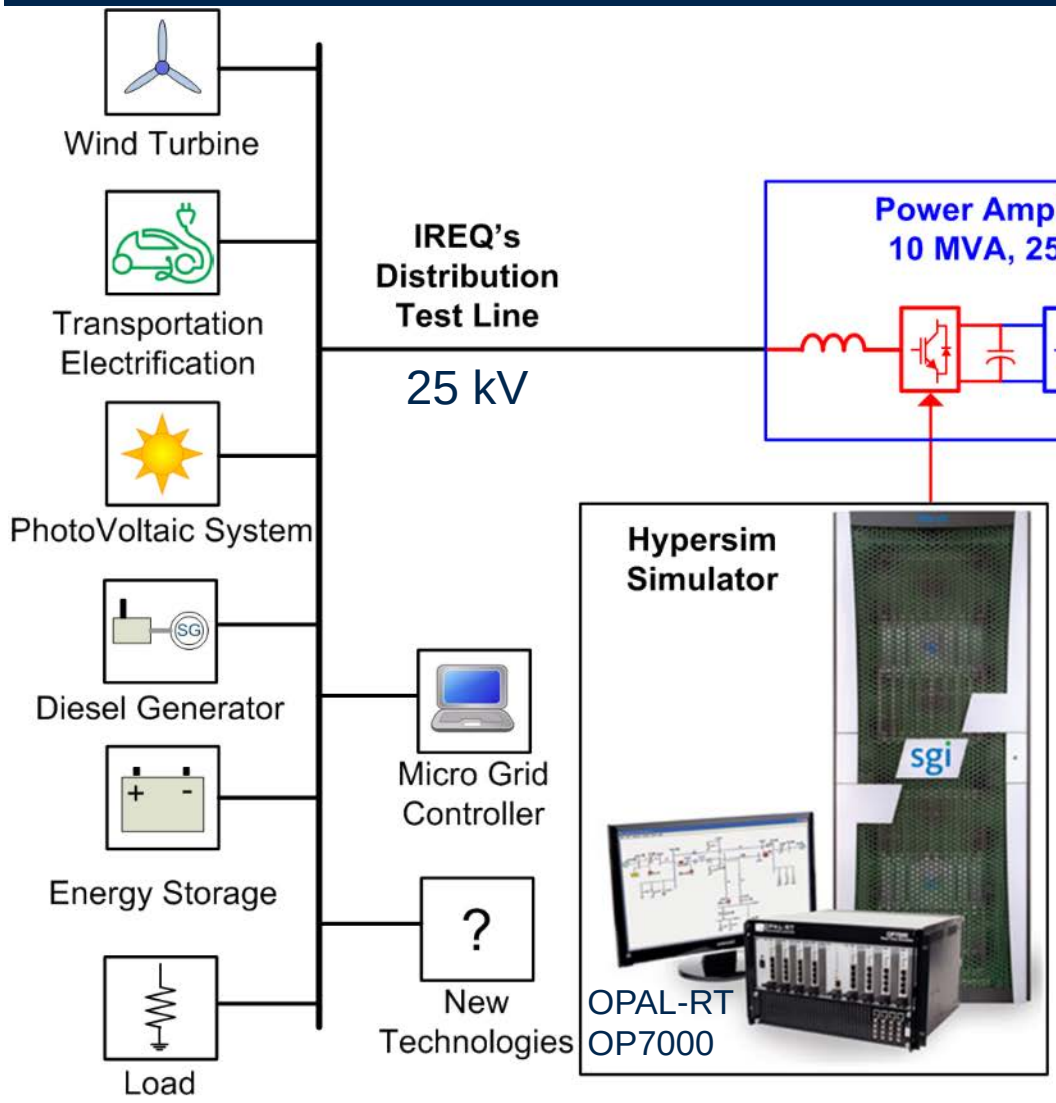
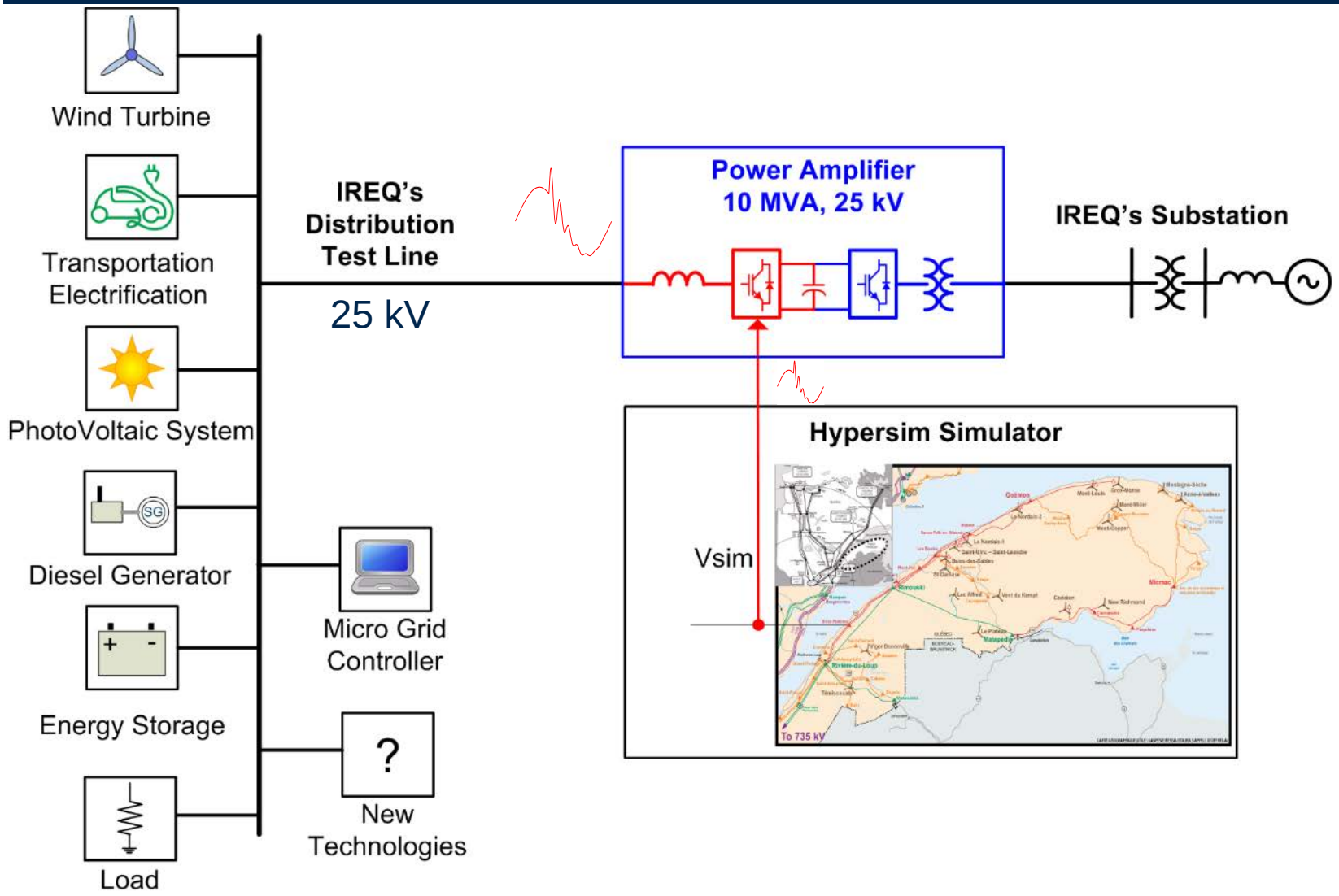


Hypersim's key features:

- Real-time simulation
- Very large network
- Automatic task mapping
- Parameters/measurements can be changed in RT
- Precise simulation engine
- Full test environment

What is it?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Hypersim Simulator
Vsim
To 735 kV

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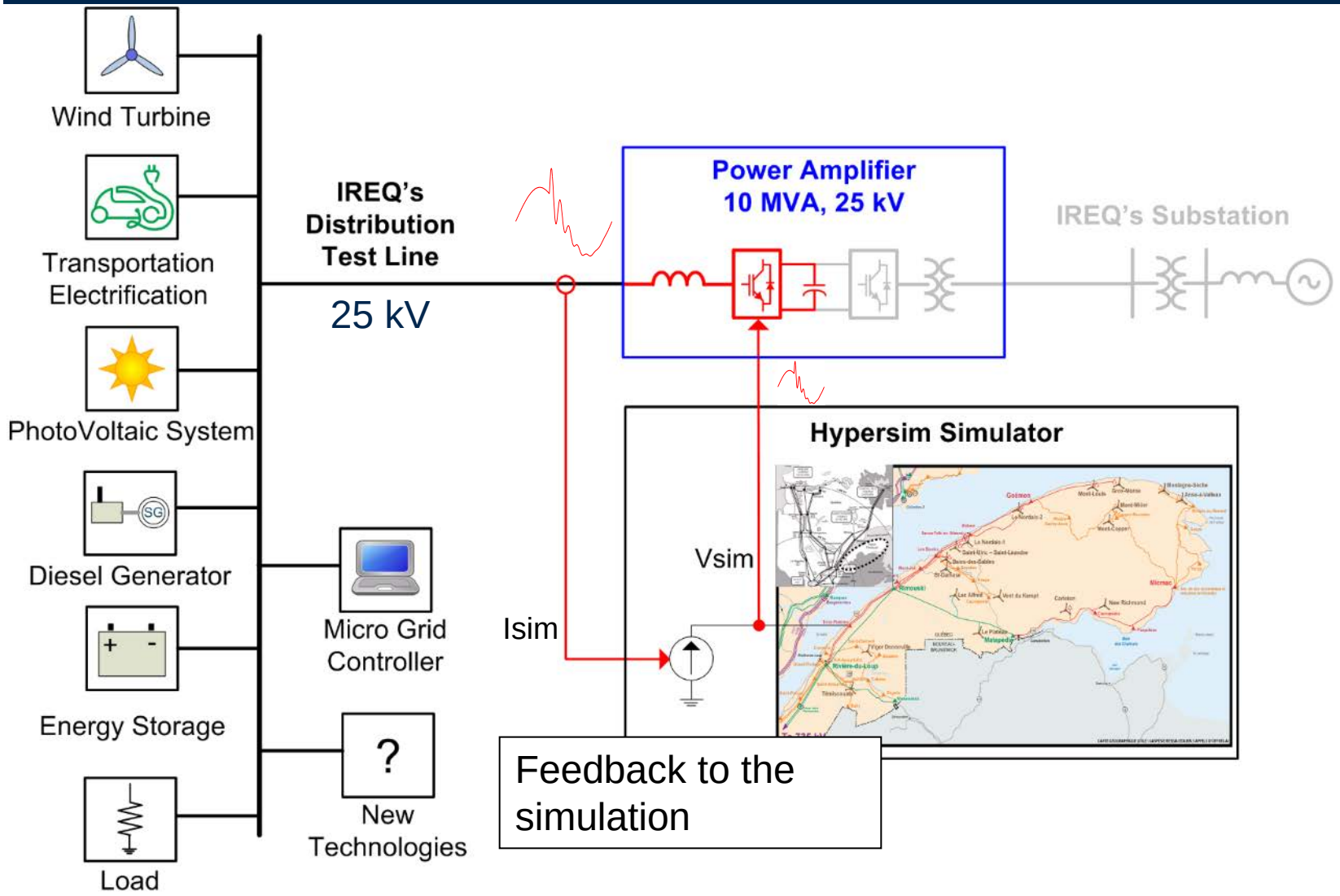
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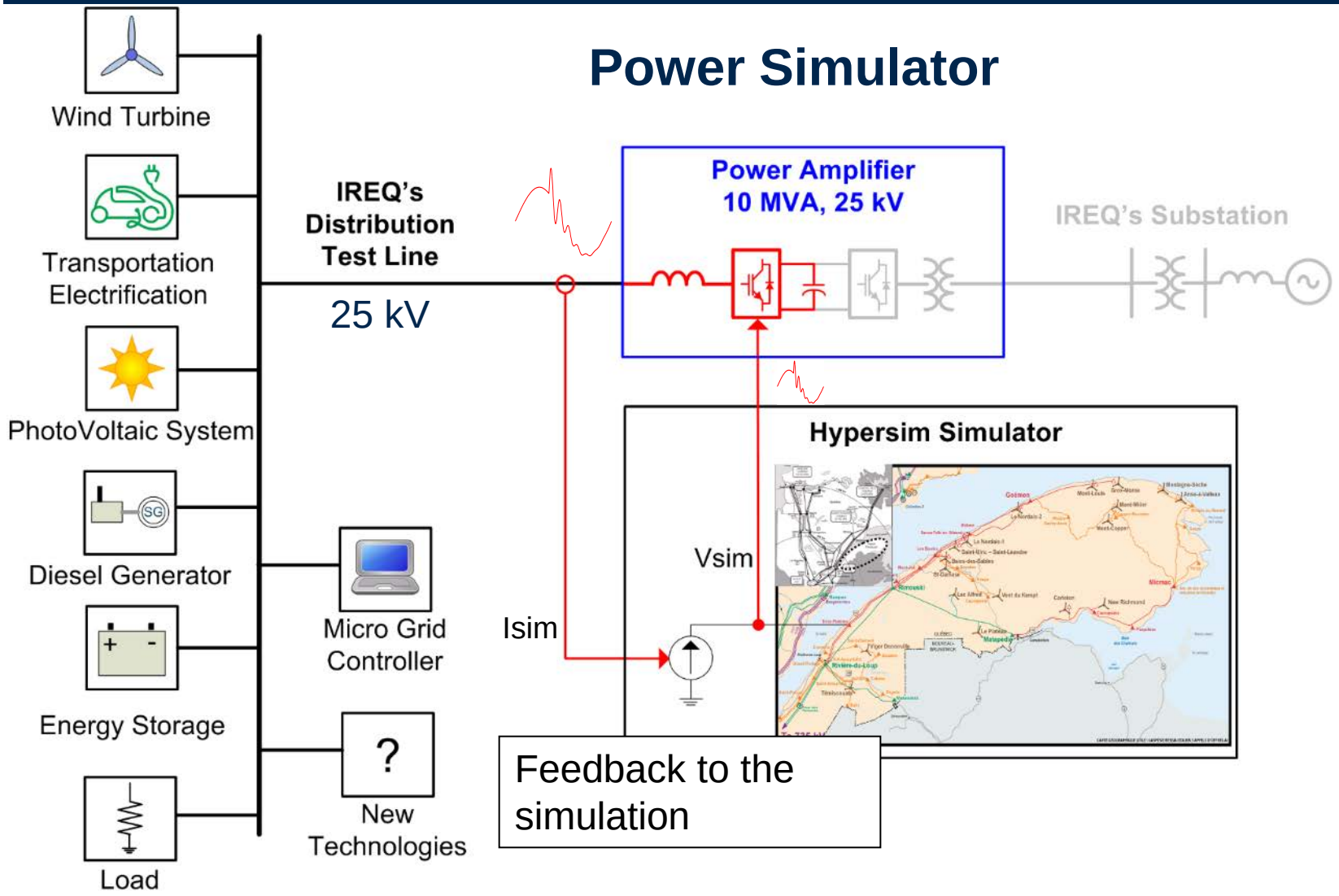
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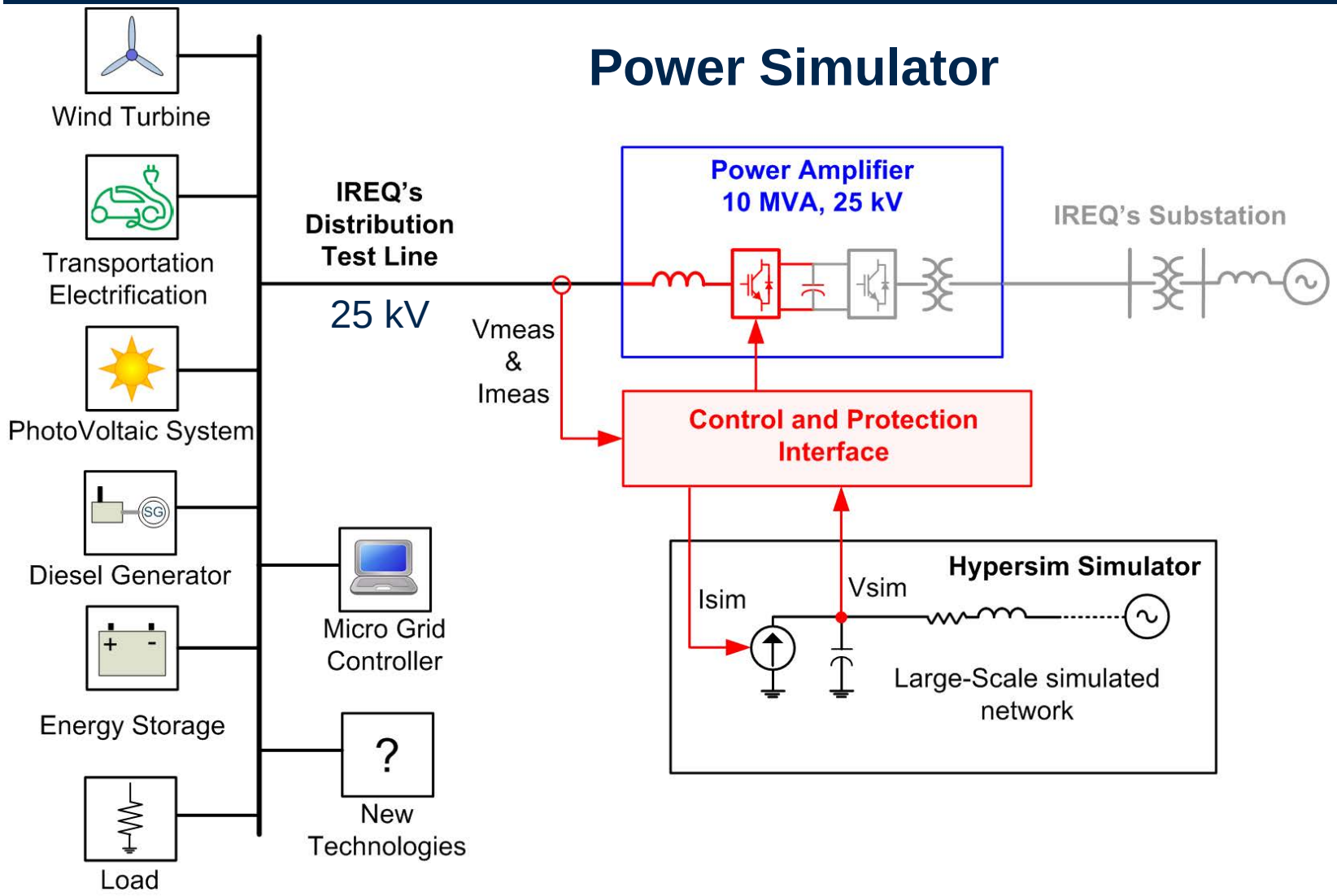
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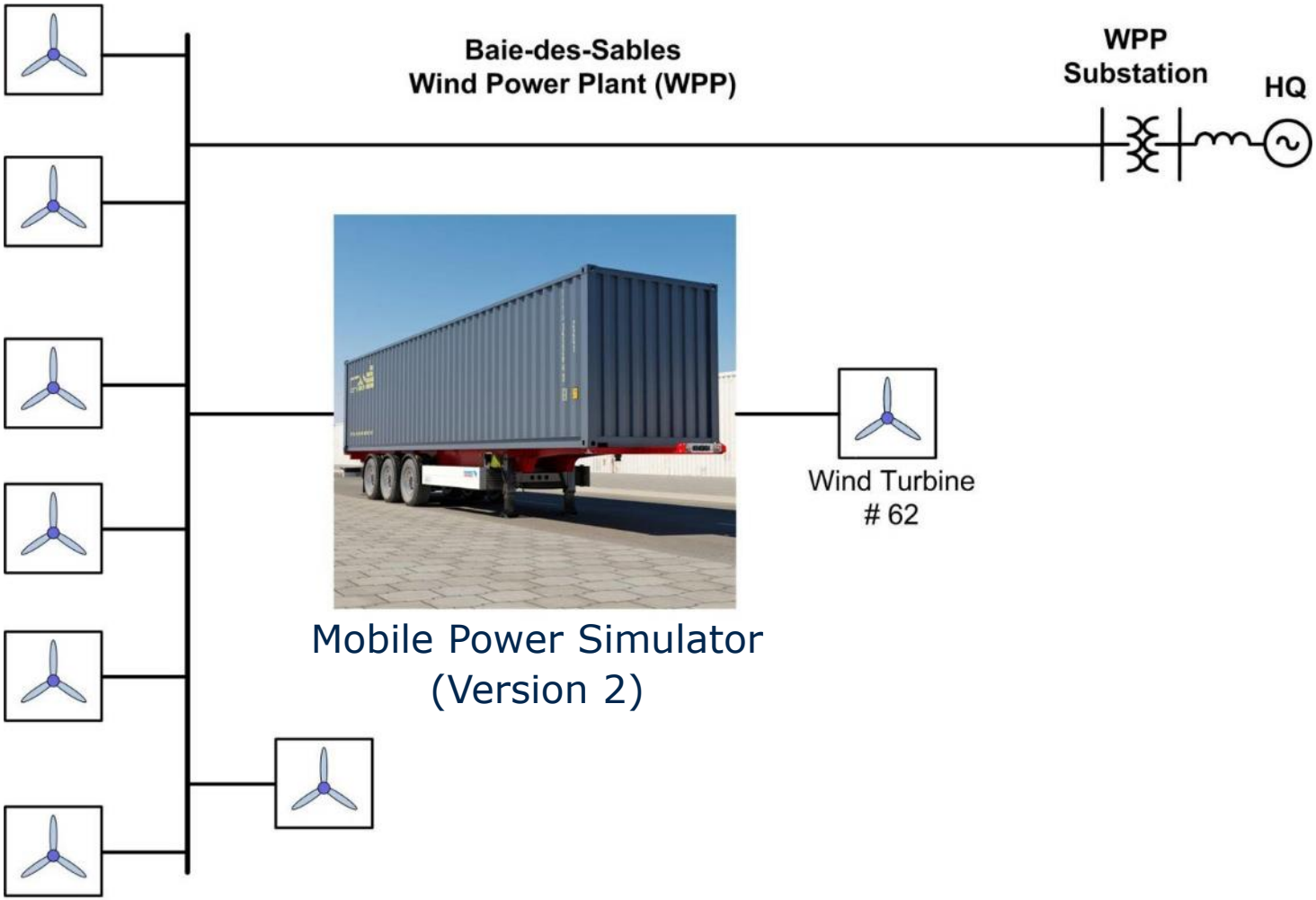
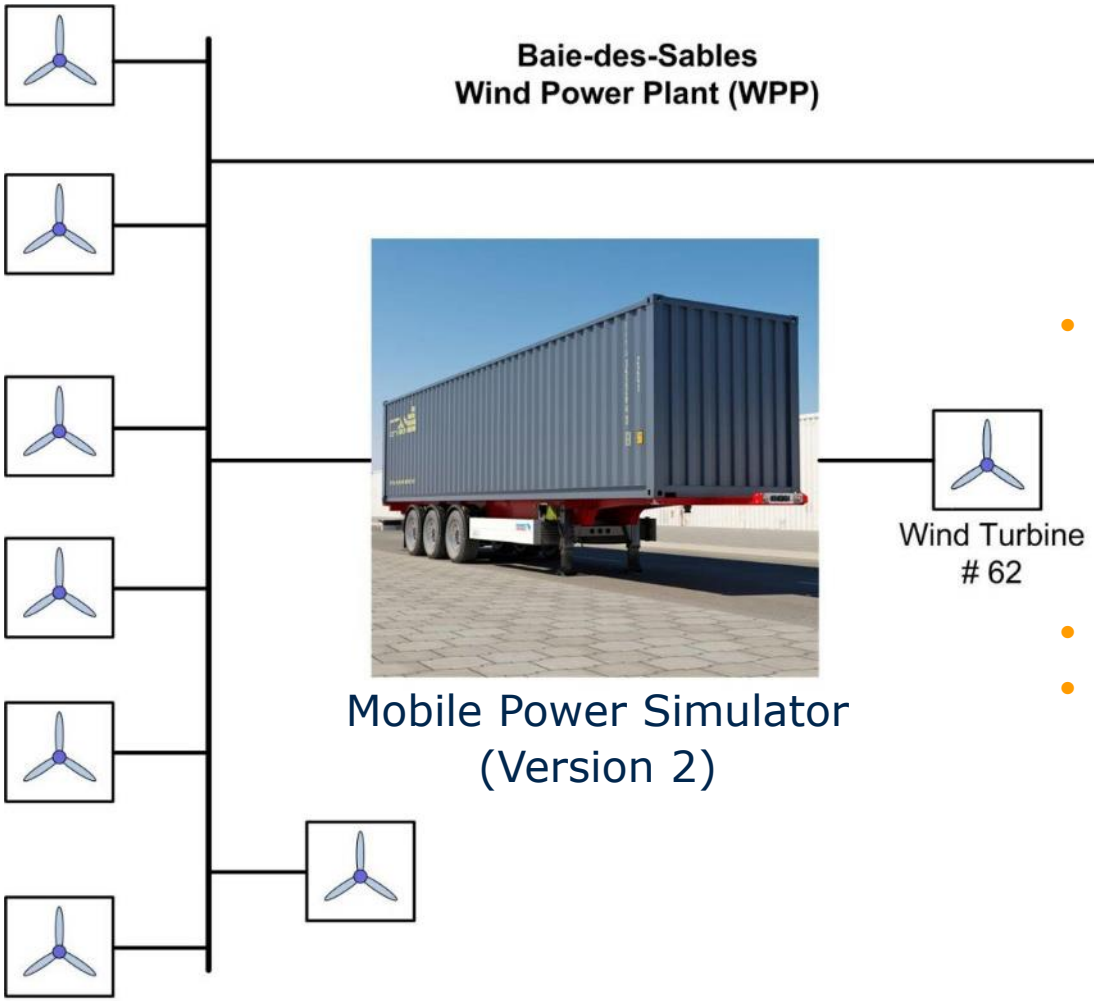
Control and Protection Interface
Hypersim Simulator
Isim
Vsim
Large-Scale simulated network

Validation of the performance of actual wind turbines



Mobile Power Simulator
(Version 2)

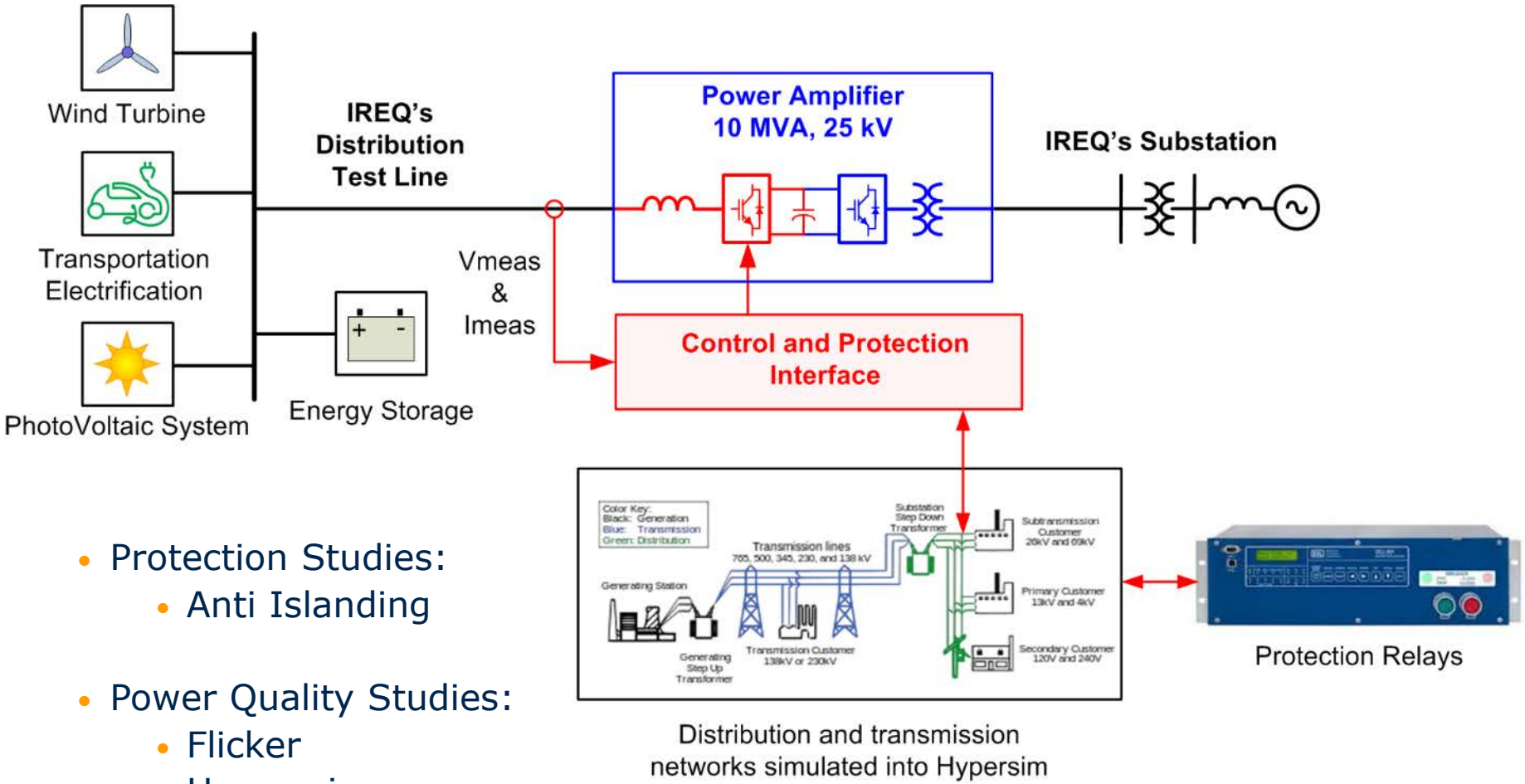
Validation of the performance of actual wind turbines



Mobile Power Simulator
(Version 2)

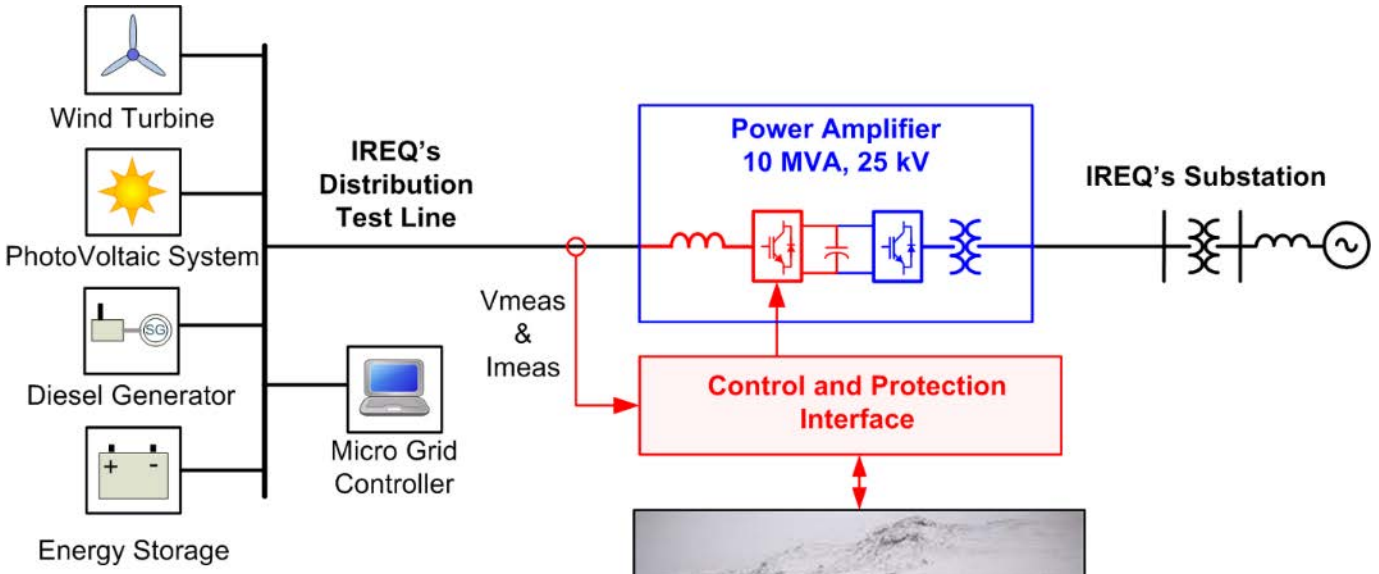
- Performances validation of wind turbines already in service
  - Voltage and Frequency (inertia emulation) control
  - LVRT, HVRT
  - Power Quality testing
- Validation of simulation models
- Characterization of the interaction with the network
  - SubSynchronous Control Interaction (SSCI)
  - Ferroresonance

Integration of renewable energy and storage to distribution networks



- Protection Studies:
  - Anti Islanding
- Power Quality Studies:
  - Flicker
  - Harmonics
  - Voltage sags

Isolated networks



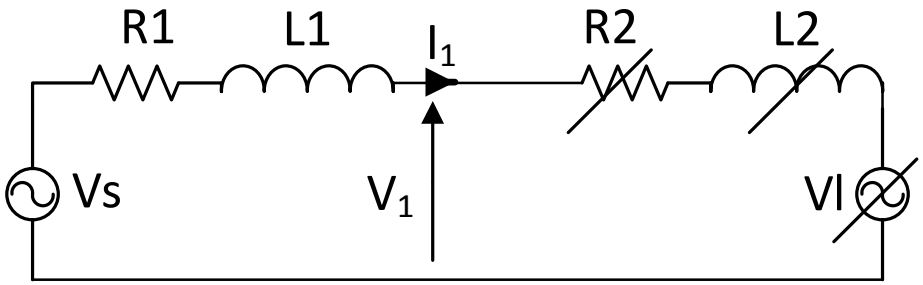
- Development of operating strategies of the integrated system: wind, solar, diesel, energy storage and load

- Performance validation before commissioning
  - Voltage and Frequency Control
  - Power Quality validation

Isolated network simulated into Hypersim

Interface issue

> Original system



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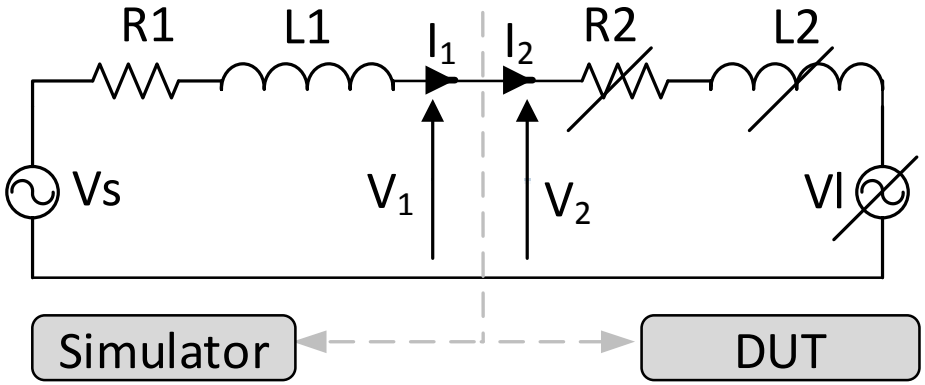

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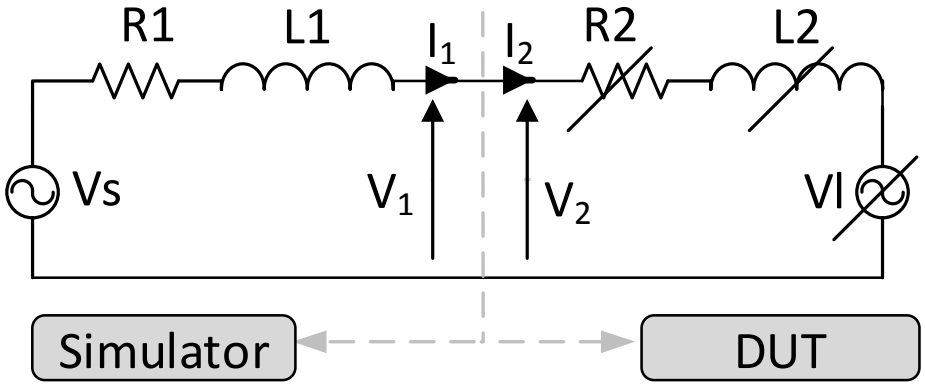
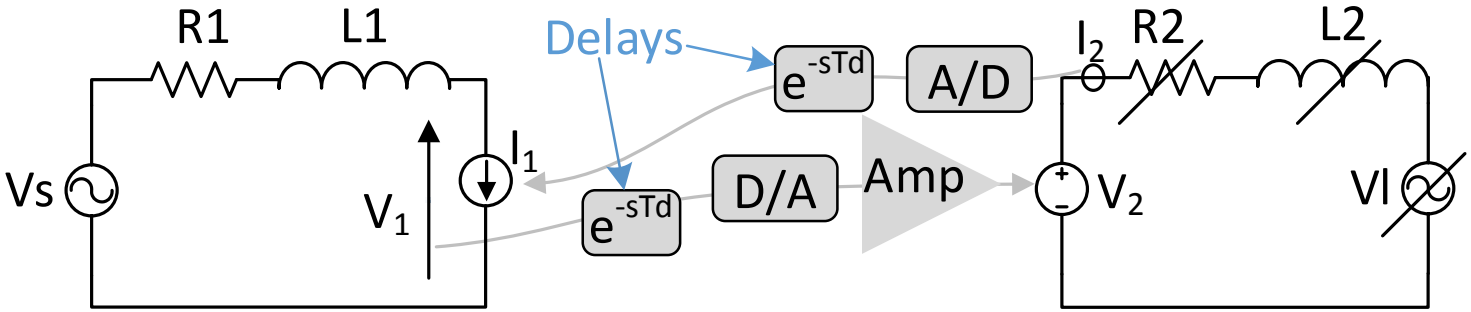


> Modified system (decoupled)



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- **Before building such equipment, we need to answer some questions:**
  - What kind of controller (FPGA, DSP) ?
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- **To answer those questions, we need a flexible reduced scale power amplifier!!**

The features of the prototype

- Single phase / three-phase
- Ideal (pure) /real voltage waveform synthesis
- Adjustable dynamics (to meet full scale constraints)
- Adjustable number of level
- Adjustable transient capability

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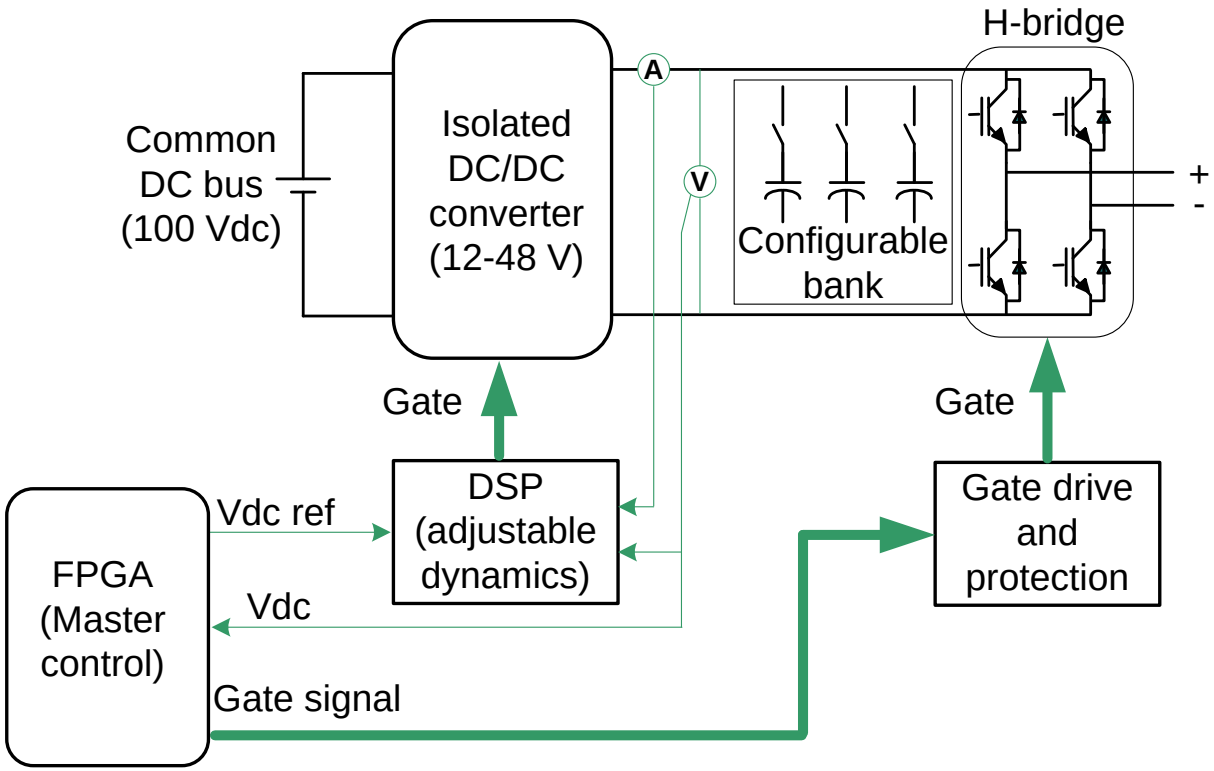
The solution: a self-powered multi-level converter

Prototype: the cell



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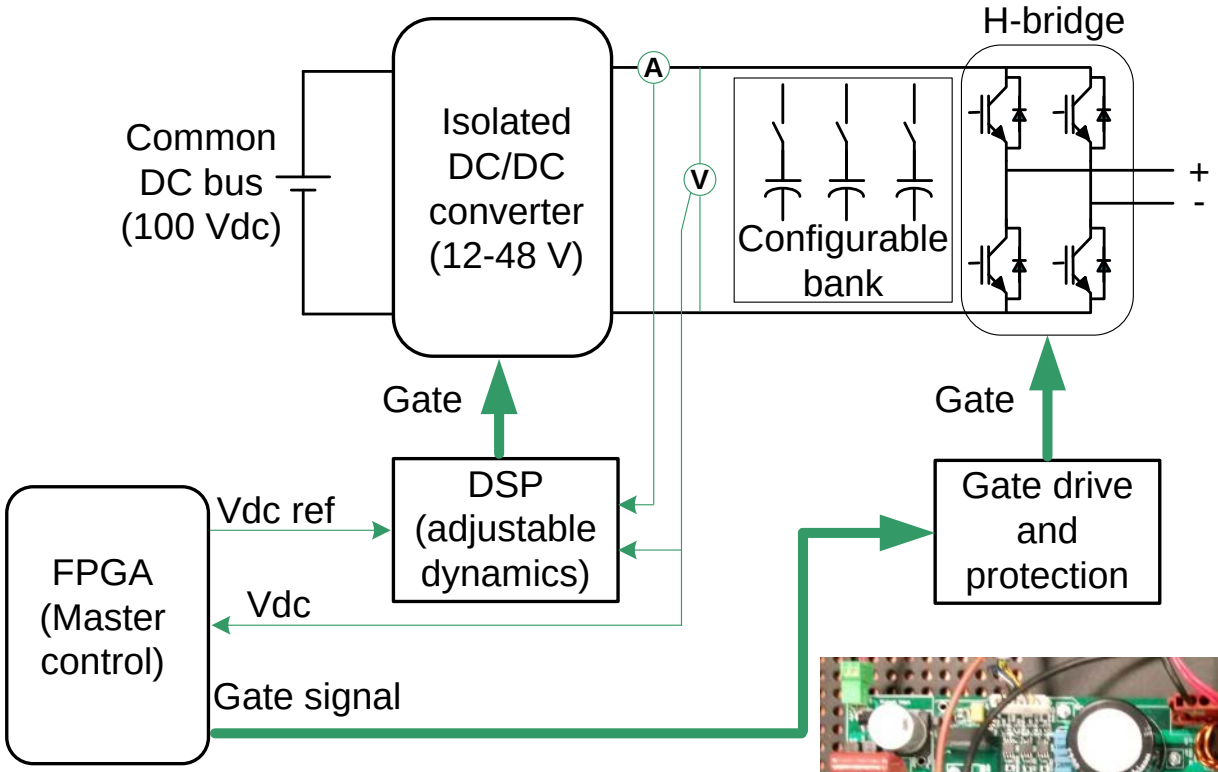

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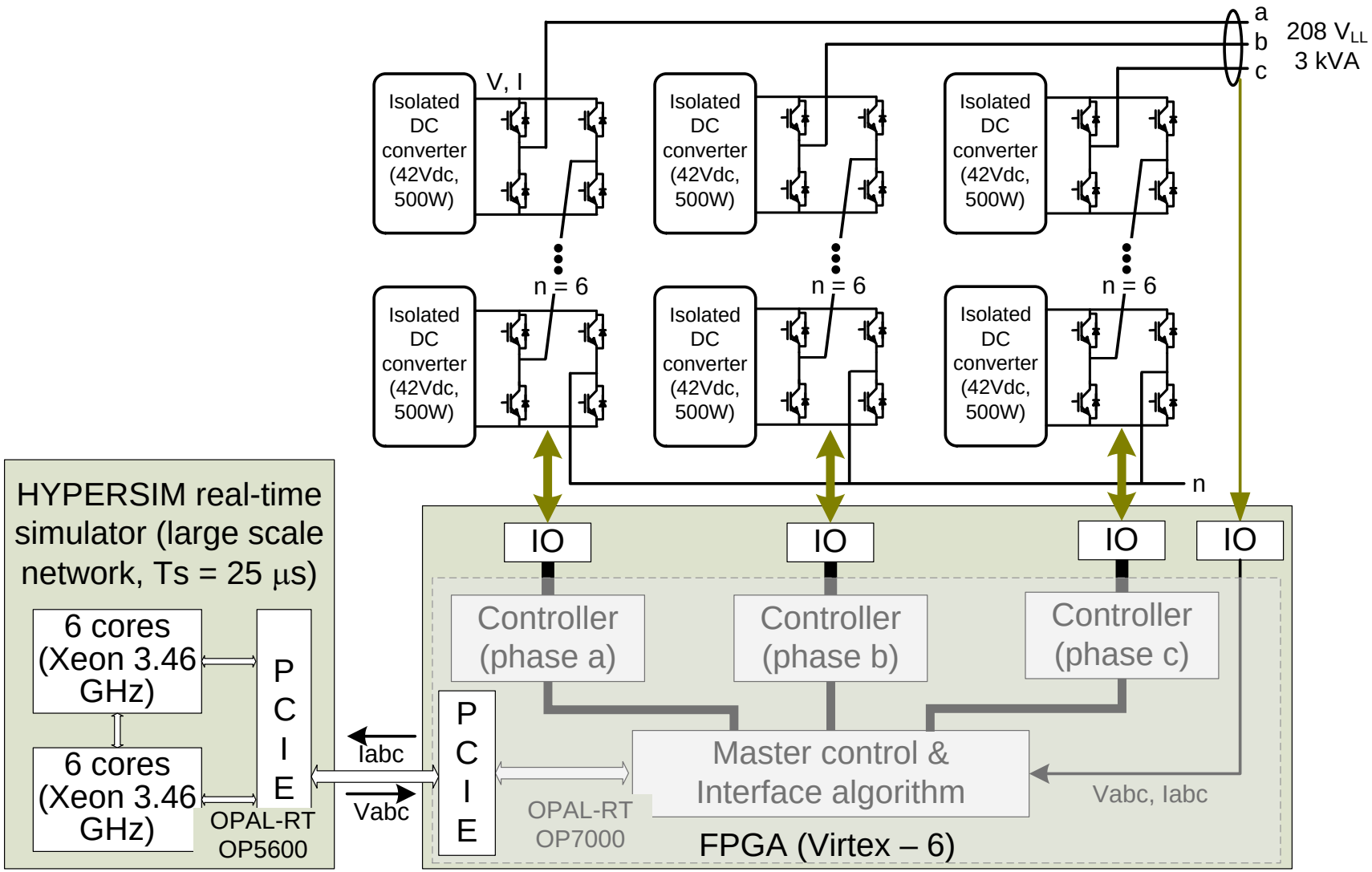


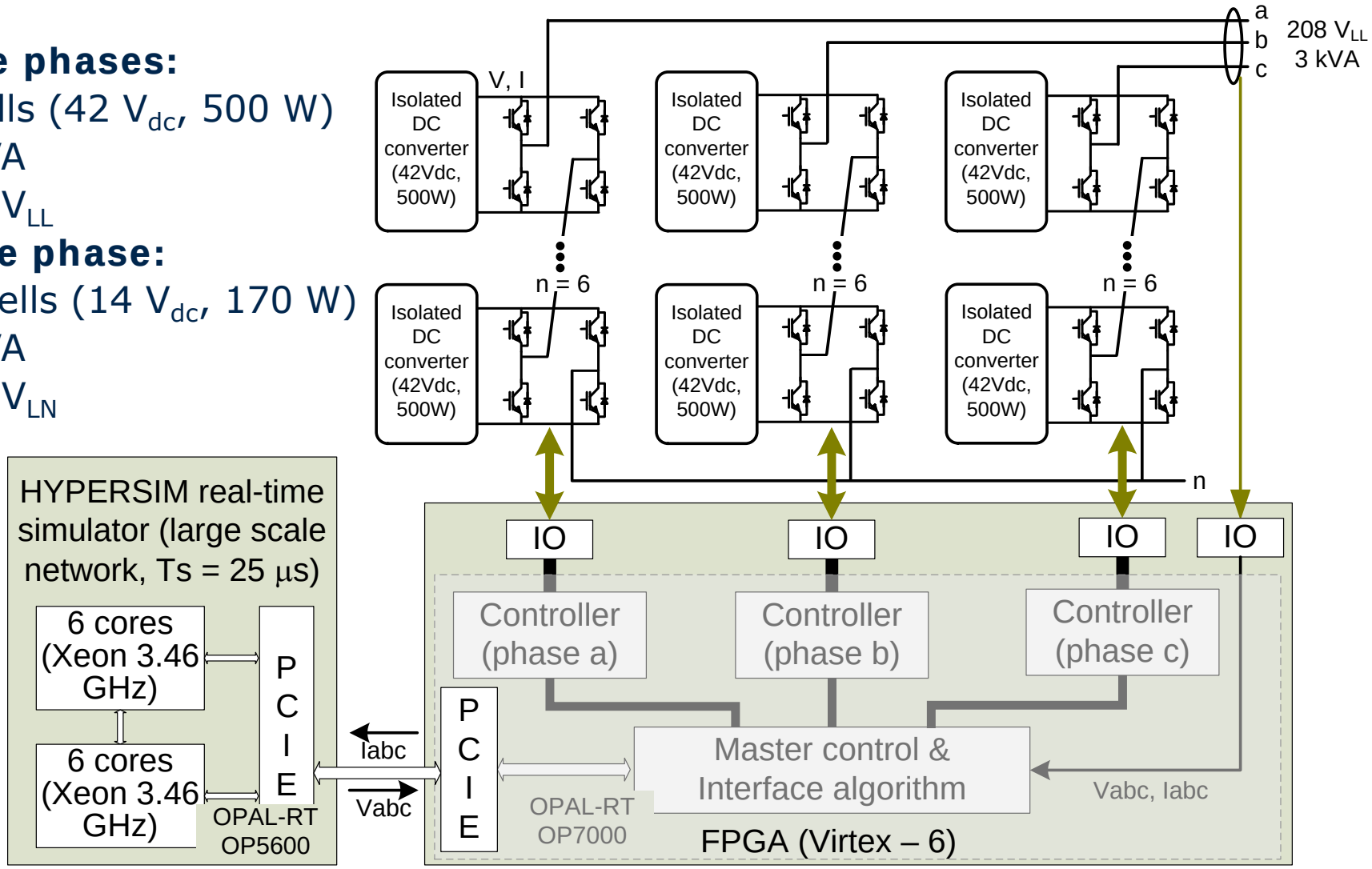
Prototype: simulator and converter

Three phases:

- >6 cells (42 V_{dc}, 500 W)
- >3 kVA
- >208 V_{LL}

Single phase:

- >18 cells (14 V_{dc}, 170 W)
- >1 kVA
- >120 V_{LN}



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- **Power Simulator:**
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- **Development of a reduced scale system to:**
  - Validate the converter controls
  - Develop a **stable, robust and high bandwidth interface** between the simulator and the power amplifier

Questions ❓

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